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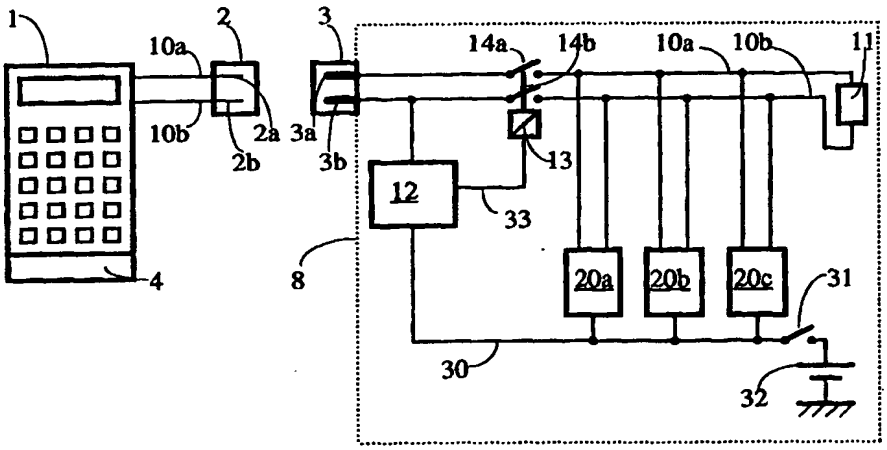

(57) Abstract

The invention relates to a safety device for diagnostic terminals (3) in distributed computer networks (8) containing at least two nodes and a common communication bus (10a, 10b) for the computer network, preferably implemented in vehicles. The diagnostic terminal enable connection of an external diagnostic equipment (1) to different nodes (20a, 20b, 20c) within the computer network. By a signal evaluation circuit (12) arranged in the computer network could a detection of the signal state at the contact pin or pins (3a, 3b) in the diagnostic terminal be made, which contact pins connects the diagnostic equipment to the communication bus. A predetermined signal state will indicate an authorised connection of a diagnostic equipment (1), and only after an authorised connection will a direct connection to the communication bus (10a, 10b) be established via a relay function (13, 14a, 14b). No additional contact pins are needed in the diagnostic terminal (3) in order to control a selective connection between the communication bus and the diagnostic equipment (1). Improved protection against unauthorised access and external disturbances from the diagnostic terminal is obtained.

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SAFETY DEVICE FOR DIAGNOSTIC TERMINALS IN DISTRIBUTED COMPUTER NETWORKS

Present invention relates to a safety device for diagnostic terminals in distributed computer networks, preferably implemented in vehicles, which diagnostic terminal enable direct access to communication busses transmitting information between distributed nodes within the computer network during operation thereof.

BACKGROUND OF THE INVENTION

Vehicles are nowadays more frequently equipped with distributed computer networks with numerous nodes monitoring different functions in the vehicle and where communication between all nodes is obtained using a common communication bus. The communication is preferably implemented in digital form with messages transmitted serially on the communication bus. Each message contain an address, also designated as identifier, and data to be transmitted to each respective node or nodes having the dedicated address. In certain type of general messages could the address be missing. With the purpose of performing a diagnostic routine of essential functions and collecting any fault messages stored in the nodes, this will require a possibility to connect an external diagnostic equipment to the system arranged in the vehicle. The diagnostic equipment could in that respect include an interface having a communication protocol being compatible with the communication bus, which will enable transmission and reception of messages on the communication bus arranged in the vehicle. In order to obtain a thorough diagnose could an activation of node functions, using the communication bus, be needed

In order to be able to connect the diagnostic equipment to the communication bus is a diagnostic terminal in the vehicle needed, said terminal establishing connection at least to the communication bus and preferably also to other systems in the vehicle. This diagnostic terminal is conventionally realised by a multi-contact plug, where a limited number of contact pins of the multi-contact plug is connectable to the communication bus. Remaining contact pins is used for monitoring or controlling purposes of other functionality's within the vehicle, which are not controlled or managed by the nodes connected to the communication bus.

In certain type of vehicle systems have dedicated nodes been implemented, i.e. Gateway-nodes, which nodes connects the diagnostic terminal to the communication link. This kind of Gateway-nodes often includes functions being able to convert data from the diagnostic equipment according a specific communication protocol used by the diagnostic equipment and to the communication protocol of the communication bus, and vice versa. Some restrictions in form or type of data to be transmitted between the diagnostic equipment and the nodes arranged in the vehicle is often obtained by such Gateway-nodes.

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In order to avoid these expensive Gateway-nodes could instead the diagnostic equipment be connected directly to the communication bus in the vehicle. With the purpose to reduce introduction of disturbances to the communication bus have been proposed to use a dedicated contact pin in the multi-pin plug as an activator which selectively could unlock a direct access to the communication bus. This will require an increase of contact pins in the diagnostic terminal, which results in increase of cost and an additional potential source for error.

SUMMARY OF THE INVENTION

The object of the invention is to prevent short-circuiting of the communication bus used in distributed computer networks, if contact pins in a diagnostic terminal connected to the communication bus should be short circuited. The invention should also prevent misapplication of voltages and other disturbances on the communication bus via the diagnostic terminal. Short-circuiting, incorrect voltages or other disturbances applied on the communication bus could during operation of the vehicle result in that essential functions could cease to operate, which as an example could lead to that the engine is shut down.

Another object is to reduce the number of required contact pins in the diagnostic terminal

Yet another object is to obtain a protection against unauthorised access via the diagnostic terminal to the communication bus in distributed computer networks

SHORT DESCRIPTION OF THE INVENTION

The inventive safety device is distinguished by the characterising part of claim 1.

By the inventive safety device could an improved protection against unauthorised access via the diagnostic terminal to the communication bus be obtained, and at the same time could the number of contact pins in the diagnostic terminal be reduced, which will improve the reliability of the distributed computer network and reduce potential sources for error during operation of the computer network or during initiation of a diagnostic routine.

Other distinguishing features and advantages of the invention are evident from the characterising part of dependent claims and the following description of preferred embodiments. Description of embodiments is made by reference to figures specified in the following list of figures.

LIST OF FIGURES

Figure 1, shows schematically a distributed computer network, and an external diagnostic equipment connectable to the computer network via a diagnostic terminal;

Figure 2, corresponds to figure 1, but with the diagnostic equipment connected to the communication bus in the computer network;

Figure 3, shows a first embodiment of circuits, by which a direct access to the communication bus could be obtained;

Figure 4, shows a second embodiment of circuits, by which a direct access to the communication bus could be obtained

Figure 5, shows an embodiment where the power supply to the diagnostic equipment is obtained via the diagnostic terminal.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In figure 1 is shown schematically a distributed computer network 8, preferably implemented in a vehicle, which computer network includes a plurality of nodes 20a-20c using a common communication bus 10a,10b for communication.

In an implementation in motor vehicles could the nodes correspond to a gearbox node, an ignition system node, a fuel system node or a brake system node, the latter preferably the ABS-system for the vehicle (ABS=Anti Blocking System for brakes).

The communication on the communication bus 10a,10b is executed serially and in digital form according a defined communication protocol. Preferably is a CAN-protocol (CAN=Controller Area Network) corresponding to the standard ISO 11898:1993 used, which protocol supports real time control and multiplex transmission. Also other similar type of communication protocols could be used, such as SAE J1850, or other protocols compatible with ISO 11519.

In figure 1 is shown a communication bus 10a,10b implemented as a differentiated dual wire according the standard ISO 11898:1993(see section 10.5). This type of differentiated dual wire includes a terminating resistor 11 between the dual wires 10a,10b. Differentiated dual wires is used in order to reduce sensitivity for noise/disturbances. In the initial state are both wires in the differentiated dual wire set at a substantially similar voltage level, and during transition to a dominant state, conventionally representing a logic "0", is the potential of one wire reduced while the potential of the other wire is increased. Any external disturbances affects both wires in a similar manner, and could thus not affect the present logical representation on the communication bus. Transmission rates up to a couple of hundred kbit per second could be used, and the transmission rate used is dictated by the response requirements on the system.

The power supply in the vehicle is obtained from a battery 32, which battery is supplying power to the nodes via the ignition switch 31.

In order to enable a proper diagnose of the computer network and the nodes thereof is a diagnostic terminal 3 available, having a first set of contact pins 3a,3b connectable to each wire in the communication bus 10a,10b. For the diagnostic routine is an external diagnostic equipment required,

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i.e. a diagnostic unit 1, having a diagnostic connector 2 including a second set of contact pins 2a,2b compatible with the first set of contact pins. When the diagnostic connector 2 is connected are the first and second sets of contact pins connected, i.e. 2a with 3a and 2b with 3b.

The diagnostic equipment 1 could have an integrated power supply 4, but could also in a conventional manner obtain power supply through dedicated contact pins in the diagnostic connector 2 and the diagnostic terminal 3, which will connect to power supply 30 within the vehicle, as shown in figure 5.

The diagnostic connector 2 and terminal 3 preferably includes a number of contact pins for a plurality of other functionality's within the vehicle. In a conventional manner are a plurality of contact pins gathered in one and the same connector/terminal, and up to an additional 20 contact pins besides the contact pins for the communication bus could exist. However, in figure 1 is only the contact pins 2a,2b and 3a,3b for the communication bus 10a,10b shown.

In figure 2 is the distributed computer network 8 shown, with an external diagnostic equipment 1 fully connected with direct access to the communication bus 10a,10b in the computer network 8. According the invention are relay switches 14a,14b controlled by a relay 13 implemented. The relay 13 is controlled by a signal evaluation circuit 12, said signal evaluating circuit being able to detect the signal state on at least one of the contact pins 3a or 3b of the diagnostic terminal 3. When a predetermined signal state is present at the contact pin, then the signal evaluating circuit is capable of activating the relay 13 in order to close the contacts 14a,14b. The signal evaluation circuit 12 is connected to power supply 30, which in a similar manner as of the nodes will be connected when the ignition switch 31 is closed.

In figure 3 is shown a first embodiment of a fundamental design of the signal evaluation circuit 12 and the signal transmitting circuits needed in the diagnostic equipment, in order to control the signal evaluation circuit 12 such that the relay 13 could be activated and close the relay contacts 14a,14b. In this embodiment is integrated with the diagnostic equipment an interface 5 for the communication bus, which interface also have the capability of activating a relay 6, or any compatible switching device of a semiconductor design. When the relay 6 close the relay contact 6a is a specific voltage applied on one of the wires, in figure 3 wire 10b, of the communication bus. The relay could preferably be activated by the interface 5 with a short pulse having a duration within the range from a couple of microseconds up to some tens of milliseconds.

By voltage division using resistors 7a,7b is obtained a voltage pulse adapted to the communication bus 10a,10b. This voltage pulse is preferably adapted in such a manner that the pulse is unique and different in relation to any normal communication on the communication bus. As an example could CAN_H (in figure 3 corresponding to 10b) in a differentiated communication bus be specified to a

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voltage up to 7.0 volts, and where correct messages never contain more than 8 consecutive bits having the same logical representation. The technique used in order to restrict the number of consecutive bits having the same logical representation is designated as "bit-stuffing" technique, and is implemented by each sending node before a message is to be sent on the communication bus. The initiating pulse activating the relay could therefore be given a potential in the order of 8.0 volts, and with a pulse duration exceeding that of 9 bits, and preferably a duration within the range 10-15 bits. Nodes being connected to the communication bus could thus detect a faulty message, and would as a consequence not be affected if the initiating pulse should be sent on the communication bus.

The signal evaluation circuit 12 being able to detect the specific initiating pulse includes two comparators 15 and 16, each obtaining an individual reference voltage via the voltage dividing net 17a-17b-17c. The first reference voltage is obtained between resistors 17a and 17b and could preferably correspond to a voltage level of 8,5 volt. The comparator 15 will thus as a consequence supply an output signal if the voltage level exceeds 8,5 volt.

The second reference voltage is obtained between resistors 17b and 17c and could preferably correspond to a voltage level of 7,5 volt. The comparator 16 will thus as a consequence supply an output signal if the voltage level exceeds 7,5 volt.

The outputs from both comparators 15 and 16 respectively are connected to inputs on a XOR-circuit (XOR; Exclusive OR), 18, resulting in that the XOR-circuit will issue an output when only one(1) of the inputs of the XOR-circuit, i.e. one of the outputs from comparators 15 and 16, is in an active output state.

The reference voltages for the comparators selected above in the example, are selected for an initiating pulse having a potential at 8 volt. If any other voltage level is selected should also each reference voltage be modified in a similar manner.

The state of the XOR-circuit, dependent of the voltage level on the wire U_{10b} of the communication bus and with an initiating pulse at a voltage level of 8 volt, as well as reference voltages according the example above, is shown in following state diagram;

Output, comparator 15	Output, comparator 16	Output XOR	Comments
0	**0**	**0**	$U_{10b} < 7,5$ volt
1	**1**	**0**	$U_{10b} > 8,5$ volt
0	**1**	**1**	$7,5 \text{ volt} \leq U_{10b} \leq 8,5$ volt

In order to obtain a functionality where an initiating pulse of short duration could activate the relay 13, and maintain the relay closed until power supply via 30 is interrupted, is a monostable flip-flop

19 used. One input of the flip-flop 19 is connected to the output of the XOR-circuit, and the other input is connected to power supply 30 via an inverter.

The output from the flip-flop 19, UT_{19} , is shown in following state diagram;

$\overline{U_{30}}$	XOR	UT_{19}	Comments
0	1	1	ignition switch activated and initiating pulse activates relay
1	0	0	ignition switch deactivated & without initiating pulse
0	0	1/0	maintain state
1	1	----	Not defined state*

* = Without ignition switch activated could initiating pulse not activate relay.

The functionality obtained is that the ignition switch must connect the computer network to power supply, and consequently also the signal evaluation circuit 12, and an initiating pulse issued after connection to power supply would activate the relay 13 and thus closing the contacts 14a,14b. The relay 13 will be kept in an activated state, i.e. with contacts closed, as long as the computer network is connected to power supply via the ignition switch 30 and if an initiating pulse have been issued. As soon as the ignition switch 31 disconnect the power supply will the relay 13 be deactivated. In order to stabilise the circuit such that disturbances, i.e. voltage spikes etc. at wire 10b, would not activate the relay 13, could a capacitor be connected to the output of the XOR-circuit 18.

The embodiment of the circuitry shown in figure 3 is only one solution out of many conceivable embodiments. In another embodiment could the XOR-circuit be replaced by an AND-circuit, with the inputs of the comparator 15 switched such that the reference voltage obtained between resistors 17a-17b instead is connected to the +input of the comparator. In yet another embodiment could the comparators 15 and 16 be replaced by a compatible IC-circuit, for example LM319(Dual voltage comparator), or LM339(Quad voltage comparator), manufactured by Philips.

In figure 4 is shown a second embodiment of a fundamental design of the signal evaluation circuit 12, and the signal transmitting circuits of the diagnostic equipment needed to control the signal evaluation circuit 12, obtaining a compatible relay function using semiconductor devices. In this embodiment is only a conventional interface 5´ for the communication bus used in the diagnostic equipment. As an initiating pulse is used a specific message for activation, which specific activation message is given an unique configuration different from any normal message. Such a message could as an example have at least 10-15 consecutive bits with identical digital

representation, i.e. without application of the "bit-stuffing" technique on the message. This message could hereby be detected by the nodes as a "faulty" message and could as a consequence not affect the functionality of the nodes.

The signal evaluation circuit 12 includes a conventional CAN-interface, 21, for a differentiated dual wire, and as an example realised by a circuit corresponding to "Philips 82C250".

In a customised IC-circuit 22 could detection of an initiating message be made, and initiating messages could be stored in a non-volatile memory 23. When the circuit 22 detects that the initiating message transmitted on the communication bus matches the initiating message stored in the memory 23, then the output 33 is activated and the semiconductor switches 13b and 13c set to a closed condition.

It is important in both embodiments shown in figure 3 and 4 that the relay functions 13,14a,14b and 13c,13b respectively, or any compatible relay-function, offer a low-resistant connection between the diagnostic equipment 1 and the communication bus. The relay function could be realised by mechanical relays or analogue relays in a semiconductor design, which do not affect the normal communication to any significant extent.

According the invention shall the evaluation function 12 be integrated in the distributed computer network, and preferably integrated in the diagnostic terminal as such, forming one single unit.

With the embodiment shown in figure 4 could a sophisticated authorisation code constitute the initiating message. Such an implementation will offer an improved protection against unauthorised access to the communication bus, in comparison with the embodiment shown in figure 3 only demanding a specific voltage level applied on either of the wires 10a,10b.

The embodiment shown in figure 3 could however improve authorised access control by implementation of a signal evaluation circuit capable of detection of a predetermined sequential pulse train. Such a pulse train, generated by the diagnostic equipment, could by way of example be formed by a number of pulses at the required voltage level, and having a predetermined duration of each individual pulse, and where each pulse is separated by a time gap having a predetermined duration.

The authorisation code could for different configuration of computer networks or car models be unique for each node configuration in the computer network. The diagnostic equipment could have several authorisation codes stored, and during establishment of connection could authorisation codes be tested until communication is established. The authorisation code used for successful connection of communication could then be used as identifier for the configuration of the computer network, and a diagnostic routine adapted for the computer network could be launched automatically.

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The authorisation code(i.e. the initiating message) could preferably be initiated manually by activation of a function- or start button on the diagnostic equipment. Alternatively could the authorisation code be sent automatically when mechanical contacts or sensors in the connector 2 detects a physical connection of the connector 2 with the terminal 3.

In yet another embodiment(not shown) could the evaluation circuit 12 be modified such that the evaluation circuit is able to transmit as well as receive messages on the communication bus. In order to improve authorisation access control further, could a verification of a correct diagnostic equipment be implemented in steps, exchanging messages between the diagnostic equipment and the evaluation circuit 12.

The invention could also be implemented in distributed computer networks having nodes 20a-20c continuously connected to power supply 32. In such a configuration could the relay 13 be deactivated using an unique deactivation message. This deactivation message could be initiated by the nodes in the distributed computer network or by the diagnostic equipment autonomously.

In the embodiments shown in figure 3 and 4 are not shown any details as of signal conditioning components, which by way of example transforms the battery voltage to a supply voltage compatible with the signal/logical level of individual components in the logic. In the embodiments shown is assumed that the battery-/system voltage corresponds to a logical representation of a "1", and a "no voltage" condition corresponds to a logical representation of a "0", if not an inverting function is implemented which would reverse the logical representation.

The invention is not limited to the embodiments shown, and could be modified within the scope of the invention as defined by enclosed claims.

The embodiment shown in figure 4 with a detection of the authorisation code by software control, could alternatively be replaced by a hardware masking procedure, designed in hardware and thus not needing any non-volatile memory. In the embodiment shown in figure 4 could the authorisation code be altered by changing the authorisation code stored in the memory 23, which memory means conventionally is denoted as a software-masking procedure when used to detect messages sent on the communication bus.

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CLAIMS

1. Safety device for a diagnostic terminal (3) in distributed computer networks (8) containing at least two nodes and a common communication bus (10a,10b) for the computer network, preferably implemented in vehicles, which diagnostic terminal enable connection of an external diagnostic equipment (1) to different distributed nodes(20a,20b,20c) within the computer network, wherein said diagnostic terminal includes a first set of contact pins (3a,3b) for a direct access to at least one communication bus (10a,10b), which communication bus transmit data between the distributed nodes within the computer network during operation thereof characterised in

- that in-between the first set of contact pins (3a,3b) and the communication bus (10a,10b) are arranged relay switches (14a,14b/13a,13b) which relay switches in a first stable position disconnects the connection between the first set of contact pins (3a,3b) and the communication bus (10a,10b),

-that the external diagnostic equipment includes signal transmitting circuits (5,6,6a/5´) which signal circuits during connection of the diagnostic equipment applies a predetermined and unique signal state on a second set of contact pins (2a,2b), which second set of contact pins are compatible with the first set of contact pins and when the diagnostic equipment is connected will connect the first and second set of contact pins together,

-that a signal evaluation circuit (12) is connected to the first set of contact pins (3a,3b) and arranged to enable detection of the signal state at the first set of contact pins and when a predetermined signal state occurs will switch over the relay switches (14a,14b/13a,13b) to a second stable position, which second stable position will close the connection between the first set of contact pins and the communication bus, whereby the external diagnostic equipment connected to the diagnostic terminal obtains direct access to the communication bus.

2. Safety device for diagnostic terminals in distributed computer networks (8) according claim 1 characterised in that the relay contacts (14a,14b) are switched over by a relay (13) activated by the signal evaluation circuit (12).

3. Safety device for diagnostic terminals in distributed computer networks (8) according claim 1 characterised in that the relay contacts is realised by semiconductor switches (13a,13b), offering a low-resistant two-way communication via the relay contacts.

4. Safety device for diagnostic terminals in distributed computer networks (8) according claim 2 or 3 characterised in that the signal evaluation circuit (12) includes a detection device (15,16,17a-17c,18) which detection device dependent of a specific voltage level, within a

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predetermined voltage range and applied on at least one of the contact pins (3a,3b), will activate the relay contacts (14a,14b/131,13b).

5. Safety device for diagnostic terminals in distributed computer networks (8) according claim 4 characterised in that the signal evaluation circuit includes at least two comparators (15,16) each comparing the voltage applied on at least one of the contact pins (3a,3b) with a first and second reference voltage respectively, which first and second reference voltages are obtained from a voltage divider (17a-17c).

6. Safety device for diagnostic terminals in distributed computer networks (8) according claim 5 characterised in that the diagnostic equipment includes signal circuits (6,6a,7a,7b) which signal circuits during activation thereof during at least a predetermined time interval will apply a voltage within the predetermined voltage range at the contact pin of concern, when the connector (2) of the diagnostic equipment is connected to the diagnostic terminal (3).

7. Safety device for diagnostic terminals in distributed computer networks (8) according claim 2 or 3 characterised in that the signal evaluation circuit (12) consist of
-an interface(21) capable of detection of at least one initiating message sent on the communication bus, which initiation message in essential parts is compatible with the communication protocol used for messages sent on the communication bus but unique in relation to any other type of message being sent on the communication bus,
- a memory(23), preferably a non-volatile memory, which memory contains an unique authorisation code for the configured computer network in question,
- a comparison circuit (2) able to compare the initiation message applied at the contact pins of the diagnostic terminal of the communication bus with the authorisation code stored in the memory, and by matching between the initiation message and the authorisation code stored in the memory (23) will establish a direct access from the diagnostic terminal (3) to the communication bus by switching the relay contacts (13a,13b) to a closed position.

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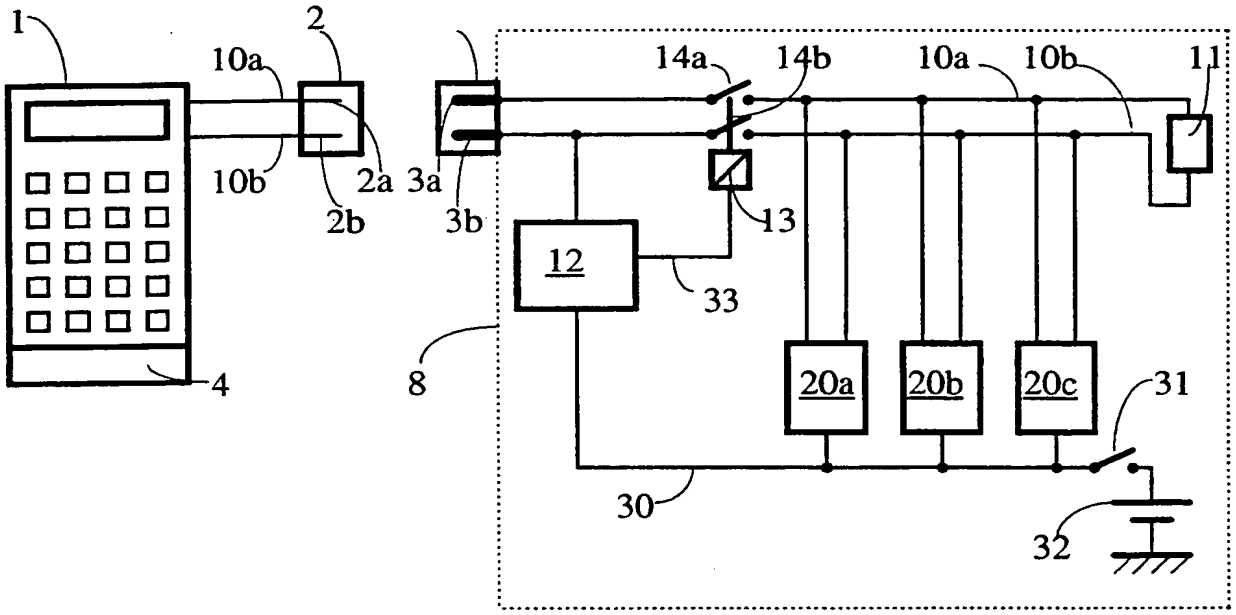
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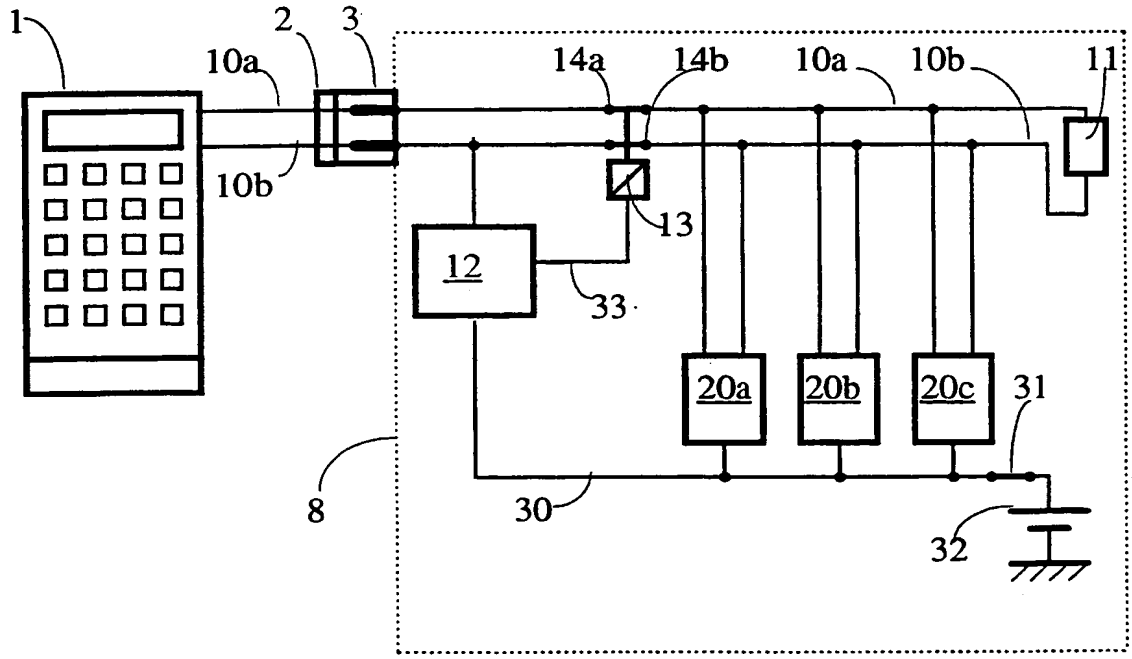
FIG.1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30
32

FIG.2

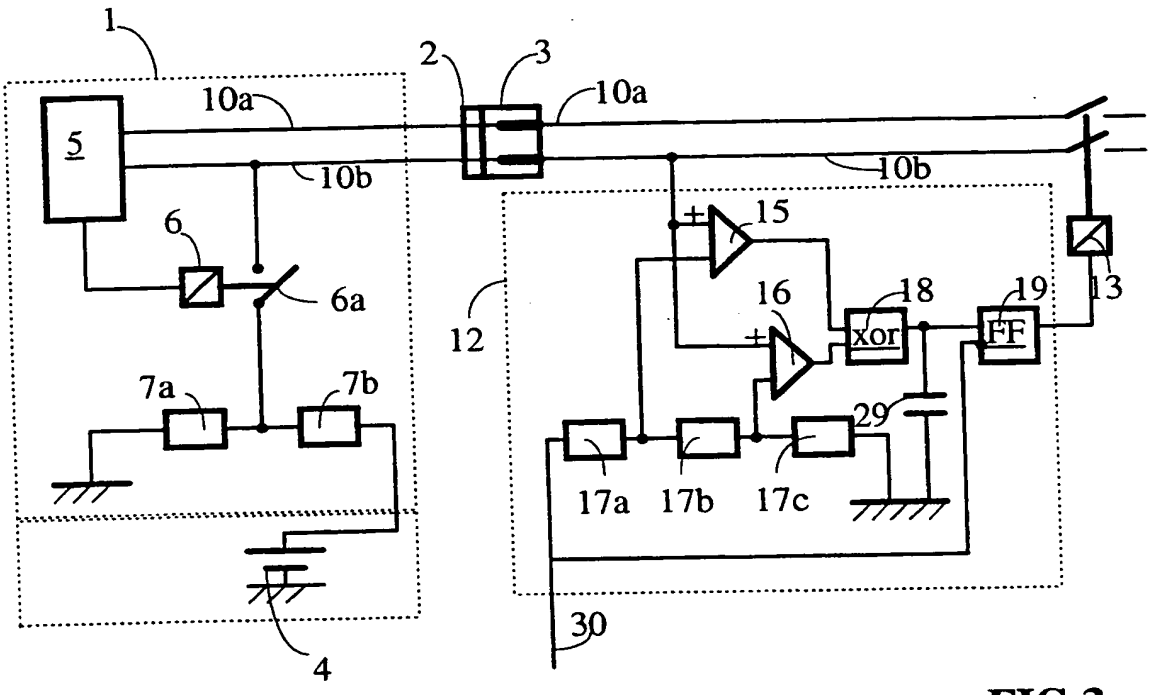

FIG.3

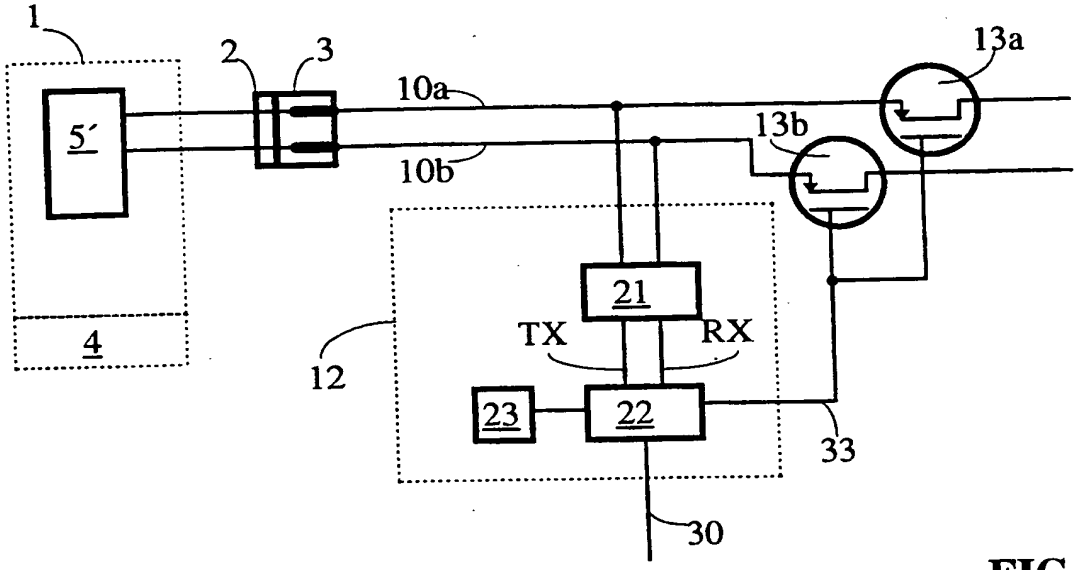

FIG.4

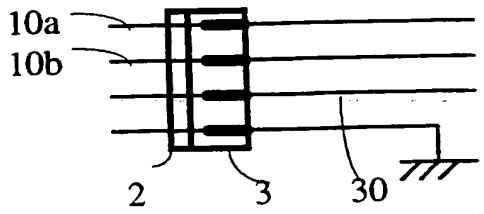

FIG.5

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/00268

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B60R 16/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B60R, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4748843 A (PETER SCHÄFER ET AL), 7 June 1988 (07.06.88), See abstract --	1-7
A	EP 0718156 A1 (TEMIC TELEFUNKEN MICROELECTRONIC GMBH), 26 June 1996 (26.06.96), See abstract --	1-7
P	WO 9706514 A1 (GENRAD LIMITED), 20 February 1997 (20.02.97), See abstract --	1-7
A	DE 4110372 A1 (MAZDA MOTOR CORP.,), 2 October 1991 (02.10.91), See abstract --	1-7

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
7 July 1998	09 -07- 1998
Name and mailing address of the ISA: Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Magnus Hjalmarsson Telephone No. +46 8 782 25 00

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International application No.
PCT/SE 98/00268

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